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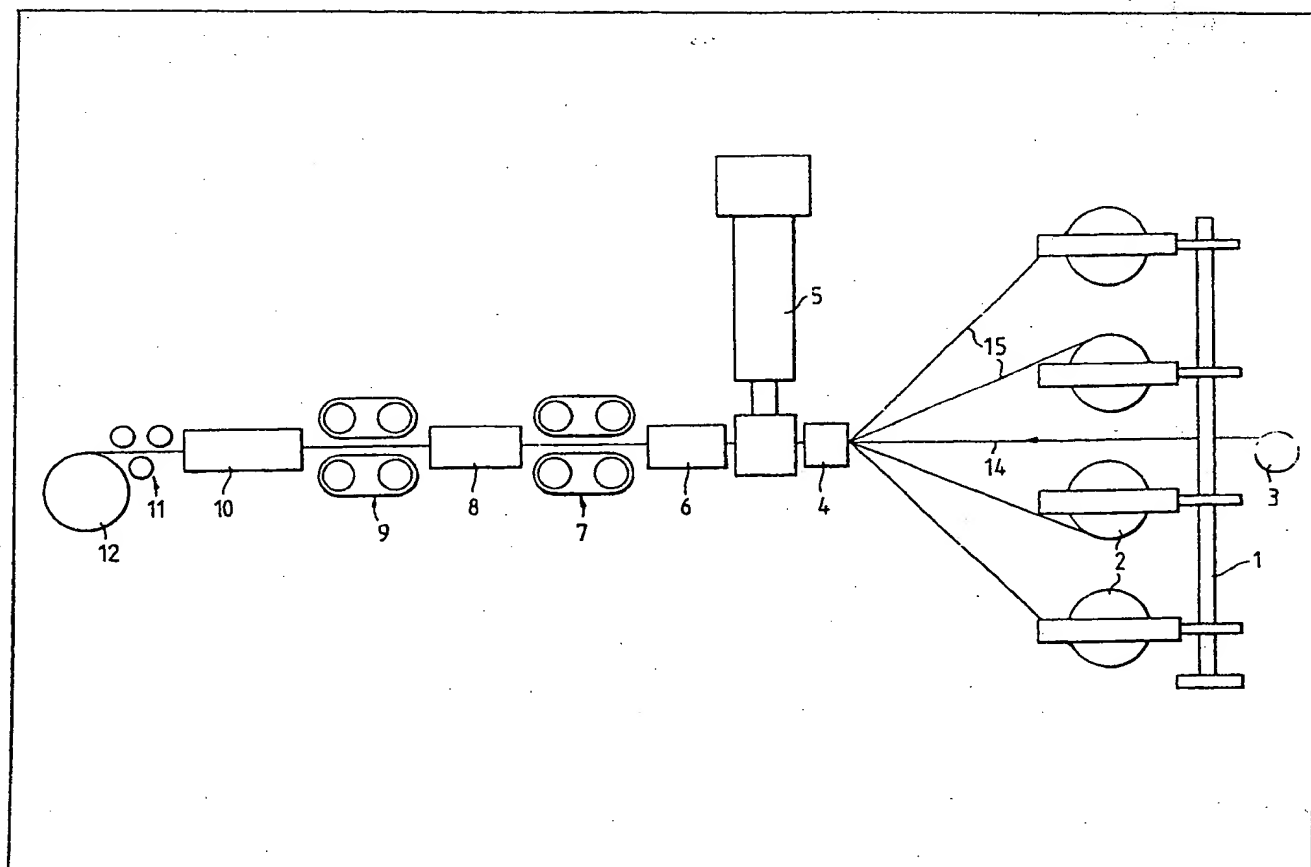
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## (54) Improvements in or relating to optical cable elements

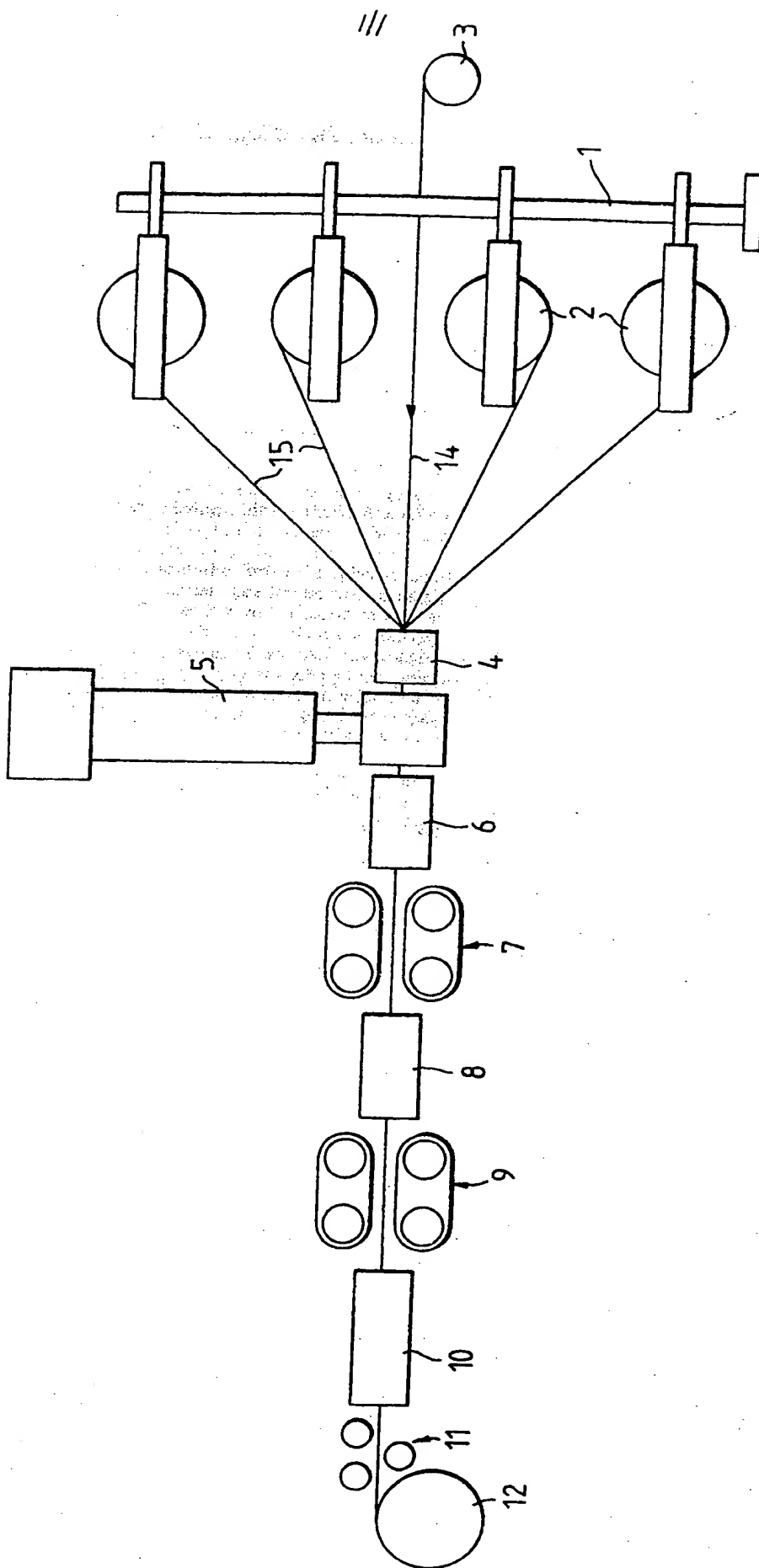
(57) An optical cable element comprising a tube of rubber or plastics material loosely enveloping an optical bundle is made by causing separate optical fibres to travel in the direction of their length, each under a controlled

tension, assembling the advancing optical fibres together to form an optical bundle in which the positions of the optical fibres relative to one another are constant and extruding a tube of polymeric material around the advancing optical bundle. The tube is extruded in such a way that its internal diameter is greater than the diameter of the optical bundle and the extruded tube is drawn down to reduce its internal diameter to such an extent that the tube loosely envelops the optical bundle. The drawn down tube is then annealed to reduce the risk of subsequent shrinkage of the tube.



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## SPECIFICATION

## Improvements in or relating to optical cable elements

Light, which term includes the ultraviolet, visible and infra-red regions of the electromagnetic spectrum, is transmitted in an optical transmission system by means of optical guides in the form of cables including one or more than one optical fibre.

One form of optical cable that is especially, but not exclusively, suitable for use in the communication field for transmission of light having a wavelength within the range of 0.8 to 2.1 micrometres includes a plurality of optical cable elements each comprising a separately formed tube of rubber or plastics material in some or all of which is or are loosely housed at least one optical bundle comprising a group of optical fibres.

An optical cable element as above described will hereinafter be referred to as "an optical cable element of the kind specified". The present invention provides an improved method of manufacturing an optical cable element of the kind specified.

According to the invention the method comprises causing two or more separate optical fibres to travel in a rectilinear direction in the direction of their lengths each under a controlled tension; assembling the advancing optical fibres together in such a way as to form an optical bundle in which the positions of the optical fibres relative to one another are substantially constant; extruding a tube of polymeric material around the advancing optical bundle in such a way that the internal diameter of the tube is substantially greater than the overall diameter of the bundle; drawing down the extruded tube of polymeric material to reduce its internal diameter to such an extent that the tube loosely envelops the optical bundle; and annealing the drawn-down tube to reduce the risk of subsequent substantial shrinkage of the tube.

Preferably, the optical bundle is formed by causing a flexible elongate reinforcing member and a plurality of separate optical fibres to travel in the direction of their lengths each under a controlled tension and by helically winding the advancing optical fibres with a predetermined length of lay around the advancing flexible reinforcing member, the rotational speed of a stranding head helically winding the optical fibres around the reinforcing member being controlled having regard to the linear speed of the central reinforcing member to give the desired length of lay of the optical fibres. At least one flexible binder tape or other flexible binder may be helically wound around the advancing assembly of reinforcing member and optical fibres before the optical bundle so formed has the tube of polymeric material extruded around it. In some circumstances, the advancing assembly of reinforcing member and optical fibres may be bonded together by means of an appropriate adhesive before the optical bundle so formed has

the loosely-fitting tube of polymeric material extruded around it. The flexible reinforcing member preferably is a single wire.

In one alternative method of forming the optical bundle, a plurality of separate optical fibres are caused to travel in the directions of their lengths each under a controlled tension with their axes lying in a substantially common plane and are retained side-by-side with respect to one surface of a flexible tape travelling in the direction of its length under a controlled tension. The plurality of separate optical fibres may be secured side-by-side between surfaces of two flexible tapes travelling in the directions of their lengths each under a controlled tension. The tape or at least one of the tapes may be transversely corrugated so that it has a plurality of troughs extending along its length with each optical fibre secured or loosely housed in a separate trough. The or each tape will usually be of paper or plastics material but, in some circumstances, it may be of metal.

Drawing down of the extruded tube of polymeric material causes the molecules of the polymeric material to line up longitudinally of the tube and such longitudinal orientation of the molecules can be enhanced by heating the extruded tube as it is being drawn down, for instance by causing it to pass through an oven. Longitudinal orientation of the molecules substantially increases the strength of the tube in a longitudinal direction so that the tube affords good protection for the loosely housed optical bundle when a plurality of optical cable elements are being assembled together to make an optical cable or when the optical cable is being installed. Longitudinal orientation of the molecules also reduces the coefficient of thermal expansion of the polymeric material to bring it substantially closer to that of the material of the optical fibres.

After the tube of polymeric material has been extruded and before its diameter is reduced by drawing down, the tube may be cooled by passing it through a cooling bath. In this case, the advancing tube is re-heated whilst it is being drawn down, and after its diameter has been reduced by drawing down, the tube may be cooled by passing it through a cooling bath.

Preferably, the optical bundle travels at a speed substantially the same as the final tube speed. Since, when the tube is wound several times around a take-up drum, the bundle is drawn into the tube by frictional forces substantially similar speeds will be achieved if the take-up drum is chosen to be of large diameter, e.g. 0.6 m. The tube is preferably drawn from the extruder and through the cooling means, and heating means when present, by at least two endless belt haul-off devices which determine the linear speed of the tube and hence draw it down to the desired cross-sectional size. The control circuit of the drive means for the endless belt haul-off devices may be linked with the output of a diameter gauge, e.g. an optical diameter gauge, to give automatic control of the drawing down operation on the tube.

Preferably, the tension in the optical cable

element as it is being wound on the take-up drum is controlled by a closed loop tension control device such as that described and claimed in our Patent Specification No: 978174. Tension control of each advancing flexible component of the optical bundle may be effected by the closed loop tension control apparatus described in the Specification of our co-pending Patent Application No: 8118053 or by any other convenient means.

With a view to reducing any risk of adhesion occurring between the extruded tube and the optical bundle, before the optical bundle enters the extruder, preferably it is dusted with French chalk or talc, e.g. by means of the dusting apparatus forming the subject of our co-pending Patent Application No: 8111997.

The invention further includes an optical cable element of the kind specified when manufactured by the method hereinbefore described.

The invention is further illustrated by a description, by way of example, of the preferred method of making an optical cable element of the kind specified, with reference to the accompanying diagrammatic drawing which shows a schematic layout of the apparatus employed.

Referring to the drawing, the apparatus comprises a carrier 1 which supports a number of pay-off reels 2 and which is rotatably driven about the axis of the machine, and upstream of the carrier, a pay-off drum 3. Downstream of the carrier 1 is an extrusion machine 5 having, adjacent its inlet end, a closing die 4, and adjacent the extrusion orifice, a trough 6 of cooling water. Two pairs of endless belt haul-off devices 7 and 9 are positioned downstream of the cooling trough 6 and an oven 8 is positioned between the endless belt haul-off devices. A second trough 10 of cooling water is positioned downstream of the endless belt haul-off device 9. Downstream of the cooling trough 10 is a tension sensor device 11 and a rotatably driven take-up drum 12.

In the preferred method of making an optical cable element of the kind specified, a central strengthening wire 14 is drawn off the pay-off drum 3 and optical fibres 15 are drawn off the reels 2 as the carrier 1 is rotatably driven about the machine axis, each under a controlled tension by a tension control device (not shown) so that the optical fibres are helically wound around the central wire 14 with a predetermined length of lay and are assembled around the wire by the closing die 4 to form an optical bundle. The advancing optical bundle passes from the closing die 4 into the extrusion machine 5 which extrudes a tube of polyethylene terephthalate around the optical bundle in such a way that the internal diameter of the tube is substantially greater than the overall diameter of the bundle. On emerging from the extrusion machine 5, the advancing tubed optical bundle is cooled by passing through the cooling trough 6. The internal diameter of the advancing tube is then reduced by drawing down the tube around the optical bundle by means of endless belt haul-off devices 7 and 9. The internal

diameter of the tube of the advancing tubed optical bundle emerging from the endless belt haul-off device 9 is such that the tube loosely envelops the optical bundle. The tubed optical bundle then passes through the cooling trough 10 which sets the tube and is wound around the take-up drum 12, the tension in the tubed optical bundle as it is being wound on the take-up drum being maintained substantially constant by the closed loop tension control device 11 which controls the motor (not shown) driving the take-up drum.

## CLAIMS

1. A method of manufacturing an optical cable element of the kind specified, which method comprises causing two or more separate optical fibres to travel in a rectilinear direction in the direction of their lengths each under a controlled tension; assembling the advancing optical fibres together in such a way as to form an optical bundle in which the positions of the optical fibres relative to one another are substantially constant; extruding a tube of polymeric material around the advancing optical bundle in such a way that the internal diameter of the tube is substantially greater than the overall diameter of the bundle; drawing down the extruded tube of polymeric material to reduce its internal diameter to such an extent that the tube loosely envelops the optical bundle; and annealing the drawn-down tube to reduce the risk of subsequent substantial shrinkage of the tube.

2. A method of manufacturing an optical cable element of the kind specified, which method comprises causing a flexible elongate reinforcing member and a plurality of separate optical fibres to travel in the direction of their lengths each under a controlled tension and helically winding the advancing optical fibres with a predetermined length of lay around the advancing flexible reinforcing member to form an optical bundle in which the positions of the optical fibres relative to one another are substantially constant; extruding a tube of polymeric material around the advancing optical bundle in such a way that the internal diameter of the tube is substantially greater than the overall diameter of the bundle; drawing down the extruded tube of polymeric material to reduce its internal diameter to such an extent that the tube loosely envelops the optical bundle; and annealing the drawn-down tube to reduce the risk of subsequent substantial shrinkage of the tube.

3. A method of manufacturing an optical cable element as claimed in Claim 2, wherein at least one flexible binder tape or other flexible binder is helically wound around the advancing assembly of reinforcing member and optical fibres before the optical bundle so formed has the tube of polymeric material extruded around it.

4. A method of manufacturing an optical cable element as claimed in Claim 2 or 3, wherein the reinforcing member and optical fibres of the advancing assembly are bonded together by means of an appropriate adhesive before the

optical bundle so formed has the loosely fitting tube of polymeric material extruded around it.

5. A method of manufacturing an optical cable element as claimed in any one of Claims 2 to 4,

5 wherein the flexible reinforcing member is a single wire.

6. A method of manufacturing an optical cable element of the kind specified, which method comprises causing a plurality of separate optical

10 fibres to travel in a rectilinear direction in the direction of their lengths each under a controlled tension with their axes lying in a substantially common plane and retaining the separate optical fibres side by side with respect to one surface of a

15 flexible tape travelling in the direction of its length under a controlled tension to form an optical bundle in which the positions of the optical fibres relative to one another are substantially constant; extruding a tube of polymeric material around the

20 advancing optical bundle in such a way that the internal diameter of the tube is substantially greater than the overall diameter of the bundle; drawing down the extruded tube of polymeric material to reduce its internal diameter to such an extent that the tube loosely envelops the optical

25 bundle; and annealing the drawn-down tube to reduce the risk of subsequent substantial shrinkage of the tube.

7. A method of manufacturing an optical cable

30 element as claimed in Claim 6, wherein the plurality of separate optical fibres are secured side by side between surfaces of two flexible tapes travelling in the directions of their lengths each under a controlled tension.

8. A method of manufacturing an optical cable

35 element as claimed in Claim 6 or 7, wherein the tape or at least one of the tapes is transversely corrugated so that it has a plurality of troughs extending along its length and each optical fibre is

40 secured or loosely housed in a separate trough.

9. A method of manufacturing an optical cable element as claimed in any one of the preceding Claims, wherein the extruded tube is heated as it is being drawn down.

45 10. A method of manufacturing an optical cable element as claimed in Claim 9, wherein, after the diameter of the advancing tube has been reduced by drawing down, the tube is cooled by passing it through a cooling bath.

50 11. A method of manufacturing an optical cable element as claimed in any one of the preceding Claims, wherein, after the tube has been extruded and before its diameter is reduced by drawing down, the tube is cooled by passing it through a cooling bath.

55 12. A method of manufacturing an optical cable element as claimed in any one of the preceding Claims, wherein the optical bundle travels at a speed substantially the same as the final speed of the tube.

60 13. A method of manufacturing an optical cable element as claimed in any one of the preceding Claims, wherein the tube is drawn from the extruder and through the cooling means, and heating means when present, by at least two endless belt haul-off devices which determine the linear speed of the tube and hence draw it down to the desired cross-sectional size.

65 14. A method of manufacturing an optical cable element as claimed in any one of the preceding Claims, wherein, before the optical bundle enters the extruder, it is dusted with French chalk or talc.

70 15. A method of manufacturing an optical cable element of the kind specified substantially as hereinbefore described with reference to the accompanying drawing.

75 16. An optical cable element of the kind specified when manufactured by the method claimed in any one of the preceding Claims.